Lesson 12 – Does Mass Change in a Chemical Reaction?

Activity 12.A

TEACHER EDITION PAGES

Preparation

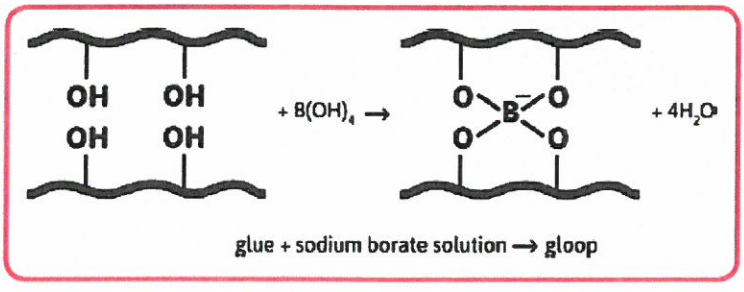
Teacher Background Knowledge

Open and Closed Systems

- Mass is conserved for all chemical reactions. On an atomic level, the numbers of each type of atom are conserved for all chemical reactions. In a closed system, conservation of mass can be measured.
- A chemical reaction in a closed system means that nothing enters or leaves the system. A chemical reaction in an open system means that something can enter or leave the system (such as gases), but atoms are still neither created nor destroyed.
- On the atomic level, a chemical reaction in a closed system means that atoms do not enter or leave the system. A chemical reaction in an open system means that atoms can enter or leave a system.
- Students are introduced to these ideas during this lesson.

Making Gloop

The reaction for making gloop can be explained by the following model. In this example, a boron atom connects to four oxygen atoms in glue molecules. This connection happens with all of the oxygen atoms in the glue molecules, to make long chains. These long chains are called polymers. The hydrogen atoms that are no longer connected to the glue molecules combine with OH-groups that were previously connected to the boron atom to form water. The molecules and the atoms that make up the molecules all have mass. From the reaction, you can see that there is the same number of atoms before the reaction as after the reaction. You can do this by counting the number of atoms to the left of the arrow and the number to the right of the arrow.



- The bubbles indicate that a gas was produced due to a chemical reaction. The mass seemed to change in the reaction because students did not measure the mass of the gas that was produced. The procedure allowed the gas to escape from the bottle without a cap, so the mass of the gas was not included in the total mass after the

reaction. Many students may think that a gas does not have mass, so this could cause confusion.

- This is a chemical reaction in an open system, so the gas product leaves the system. Conservation of matter cannot be measured in an open system. However, atoms are not destroyed. In an open system, you do not mass all of the substances. Students need to use a closed system (a capped bottle) to test whether or not conservation of matter holds for this reaction, which is the focus of Lesson 13.2. In a closed system, none of the substances can escape, so the mass of all the atoms can be measured.
- Do not give students the caps for the soda pop bottles in Activity 13.1. Save the caps for Activity 13.2. Students should complete this investigation in an open system. In 13.2 they will repeat the same reaction in a closed system.

Writing about Conservation of Mass

In previous lessons, students have constructed arguments as to whether two things are the same substance or about whether a new substance was produced (chemical reactions). Since this is the first time students have written an explanation or argument for a question about whether mass changes, they may be confused by what counts as evidence and reasoning. You may wish to stress the importance of including the actual numbers for the mass in the evidence. You also might want to discuss that since students do not know as many science principles or theories about whether mass changes in a chemical reaction (since it is a new topic) that they will not have as many science principles to include in their reasoning. Students should still use their observations (about the bubbles) to include some reasoning. The bubbles indicate that a gas was produced due to a chemical reaction. The mass seemed to change in the reaction because students did not measure the mass of the gas that was produced. The procedure allowed the gas to escape the bottle without a cap, so the mass of the gas was not included in the students' total mass after the reaction.

Common Student Ideas

- Students may think that mass changes during a chemical reaction based on their everyday experiences. For example, they may think that mass changes when materials burn or rust because the reactants seem to get used up or the products are added. They may think that the materials disappear or appear.
- Student perception of mass (if they confuse the terms density, weight, and mass) may influence what they think happens to mass during a chemical reaction.
- Students may not understand that mass is conserved during a chemical reaction that involves gases as reactants or products if they do not believe that gases have mass (IQWST IC1).
- Students should be learning that language such as *appear* and *disappear* is inappropriate for describing matter in chemical reactions. Atoms (matter) cannot be created or destroyed. Likewise, in earlier lessons, students learned that dissolving is not a chemical reaction. One substance dissolved in another gives a mixture. However, students have been told that a seltzer tablet is a chemical reaction and not a mixture. If students suggest that the seltzer tablet dissolved in water, probe their thinking about dissolving.

Setup

Preparation

Optional Activity 12.A

- Prepare the sodium borate solution by mixing 20g (1/6 cup) of laundry borax (sodium tetraborate decahydrate, $Na_2B_4O_7 \cdot 10H_2O$) into 1L (about 1qt) of water while stirring. All of the borax may not dissolve.

Materials – Activity 12.A (Optional)

For Each Student

- Activity Sheet 12.A
- (1) 8oz plastic or paper cup
- 6 tsp (30mL) white glue
- 5mL water*
- 15mL sodium borate solution (liquid laundry starch)
- (1) craft stick
- (1) graduated cylinder
- (1) mass balance
- plastic bags

*This item is not included in the kit.

TEACHING THE LESSON

Performance Expectations

Students will

- design and carry out an investigation to investigate what happens at the macro- and microlevels in a chemical reaction in an open and a closed system, thus experiencing conservation of matter.
- use data as evidence to construct an explanation of the principle of conservation of mass.

Building Coherence

Begin Learning Set 3 by building on understanding of chemical reactions (atoms rearranging) to address conservation of matter in open and closed systems, and the final subquestion: Do new substances always come from old substances?

Timeframe

2 Class Periods (optional activity 12.A adds an additional class period)

Overview

Activity 12.A (Optional)

Make gloop as a way to investigate whether mass stays the same or changes during a reaction that does not involve a gas.

Activity 12.1

Investigate whether measuring the mass of reactants and products when a seltzer tablet reacts with water could provide evidence of whether new substances always come from old substances.

Activity 12.2

Design and carry out an investigation to account for the mass of the gas produced in the seltzer tablet reaction in a closed system to learn about conservation of matter.

Introducing the Lesson

Activities address the last section of the unit: Do new substances always come from old substances?

- What happens to the atoms in a chemical reaction? *(Atoms we start with—in reactants—combine in new ways so the substances we end up with—products—have different properties.)*
- Where do the new substances come from? *(the atoms of the old substances; reactants)*
- Could the new atoms come from somewhere else? *(Atoms need to come from somewhere; they cannot just appear.)*
- Would you expect the mass of the reactants to be the same or different from the mass of the products after a chemical reaction?
- Provide an example or two from class: Do you think the mass of the copper and acetic acid had the same mass as the copper acetate and hydrogen gas produced during the reaction? *(Mass stayed the same because there were the same number and type of atoms before and after the reaction; mass decreased because there was air that escaped or because gases have less mass; mass increased because there was another substance on the copper square so the copper square had greater mass.)*

Describe: If the mass of the new substances and the old substances were the same, this would be evidence that new substances always come from old substances. If the mass of the new substances is greater, this suggests that the new substances are coming from somewhere else and new matter is being created. If the mass of the new substances is less, it suggests that some of the new substances are escaping or that matter is destroyed. Therefore, mass is important data as to whether mass can be created or destroyed in a chemical reaction.

Activity 12.A – Making Gloop (Optional)

Students conduct an experiment to test whether mass stays the same or changes in a chemical reaction. Review the procedure on Activity Sheet 12.A. Write the following reaction on the board:

Reactants → Products

glue + water (H_2O) + sodium borate in water → gloop

Groups carry out the activity, then share observations and discuss responses to the following conclusion questions:

- What happened to the mass in this reaction? *(It did not change.)*
- Do you think mass stays the same in all chemical reactions?
- Can you think of any reactions where it would not stay the same? Explain your ideas.

In the next activity, students will explore a different chemical reaction to determine what happens to mass.